Reply to comment on “EM De-embedding Magic – Part I: What’s the Problem, Anyway?” by James C. Rautio

Failure modes are a topic to which I have devoted considerable effort. Engineers are interested in what can go wrong. Whenever everything works, we lose interest in that topic and go on to the next problem.

Part III of this series is subtitled, “What Could Possibly Go Wrong?” Details will be presented there, and in even more detail is in [1]. High level, the port connecting lines are not allowed to be over-moded. If there is a single transmission line connecting ports 1 and 2, then there can only be one mode communicating power between the ports. (What happens with multiple coupled port connecting lines is described in Part II.)

Radiation is a higher order mode, which is not included in the de-embedding model. If you want to de-embed through a radiating transmission line, you will need to develop a different technique (a good research project). This might be useful for antennas. My focus is microwave circuits. If a microwave circuit contains a radiating transmission line, the designer has likely made a design error.

Failure of the calibration/de-embedding algorithm is easily detected by several techniques described in Part III. Failure usually indicates a flawed (radiating or otherwise over-moded) circuit design.

Unshielded port calibration can be accomplished by various techniques that assume a general port discontinuity. These techniques are more susceptible to error when the port connecting lines are a multiple of one half wavelength long. This is because it is difficult to discern the difference between the per unit length L and C of the transmission line and the L and C of the general port discontinuity. In addition, unshielded planar EM analyses typically use an approximate Green’s function, and it can be difficult to establish an exact short circuit reference plane.

In contrast, the shielded planar Green’s function is a sum of sines and cosines. It is evaluated to full numerical precision by means of the FFT. In addition to being essentially exact, the time required for the Green’s function evaluation is usually completely inconsequential in the overall analysis time. As for establishing reference planes, a shielded EM analysis has perfect short circuits for setting exact reference planes easily available in the form of the conducting sidewalls. This provides all ports with an exact reference plane and an exact ground reference, with all ports having exactly the same ground reference.

Reference

[1] G. Crupi, and D. M. M. -P. Schreurs, editors, Microwave De-Embedding – From Theory to Applications, Elsevier, 2014, Chapter 4, pp. 151–187. http://store.elsevier.com/product.jsp?isbn=9780124017009&pagename=search